EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH GLASS POWDER AND MARBLE DUST IN CONCRETE

Ravi Nandal[1], Dr. Sanjay sharma[2] Dr. Amit Goyal[3],
[1](M.E. Student, Civil Engineering Department, N.I.T.T.T.R. Chandigarh) [2] (Professor, Civil Engineering Department, N.I.T.T.T.R. Chandigarh,)
[3](Asst. Professor, Civil Engineering Department, N.I.T.T.T.R. Chandigarh,)

***Abstract* — The current study involves the partial replacement of cement (varying proportion) with marble powder (4, 8%, 12% and 16%) and glass powder (4, 8%, 12% and 16%) to generate sustainable concrete. The Slump Test, Compressive Strength Test, Split Tensile Strength Test and Flexural Strength Test were carried out and the results were collected. The outcome of the current work is that the waste material marble powder and glass powder help in increasing the compressive strength by approximately 8%, split tensile strength by 18% and flexural strength by 9%. Therefore, it is recommended that 8 to 12% of glass powder with 8 to 12% of marble powder can be used as an effective replacement material for cement in concrete mix to attain improved strength parameters.**

Keywords— Concrete, Glass Powder, Marble Powder.

I. Introduction

Concrete is one of the several extensively adopted modern construction materials. Concrete is an “artificial material” which is produced by blending different proportions of cement, sand, and aggregates while water is added gradually. Fresh (softened) concrete can be made into any form, which is the major advantage of this material. Concrete became common when Portland cement was invented in the 19th century, but due to its weak tensile strength, its usage was kept to very limited construction projects. With much research work, the problem of less tensile strength was overcome when the steel bars were introduced by embedding in concrete mass. This composite material was then called reinforced concrete.

The environmental consequences of the production and utilization of concrete are complicated as some of them are positive and some of them are detrimental. Although Concrete has become the most impeccable material in the construction industry, one cannot ignore the deleterious impacts of concrete on Mother Nature. The main ingredient to concrete is cement and aggregates. Almost all the negative impacts are due to using of these raw materials in concrete. The release of harmful gases is one of them. The cement enterprise produces an enormous amount of carbon dioxide (CO2), generating almost 8% of total carbon dioxide emission, out of which, half is produced by the chemical method and almost 40% results from burning fuel. The estimated generation of carbon dioxide when the 1m3 of concrete is used is 410 kg (approximately 180 kg/ton at density=2.3 g/cm3). This outcome can be reduced if cement is replaced by fly ash up to 290 kg (30% fly ash replacement). The cement content used in concrete production directly gives the idea of the production of carbon dioxide. Almost 900 kg of carbon dioxide is being released when 1 ton of cement is manufactured. Moreover, greenhouse gases are produced when the decomposition of calcium carbonate takes place thermally, which results in the generation of lime and carbon dioxide. Moreover, the utilization of different forms of energy, especially from the combustion of fossil fuels.

Waste from glass waste is one of the significant predicaments which have serious effects on the environment which is occurring in each nation at large scale as the glass waste is not biodegradable, and the capacity to initiate a harmful impact on the environment by creating pollution. Furthermore, the disposal of such waste material is another issue which a nation is facing in the modern world and the quantity of such material is huge due to the huge population in each country. Therefore, a large area is required for such disposal. The modern answer to this problem is to utilize this waste material in one way or the other so that environmental impact shall be reduced in numerous ways. The method of recycling and reusing glass wastes entails myriad gains for the environment and other raw and natural resources on earth. Moreover, the spaces which were required for disposal can be now used for some other development work of the nation. The impeccable use of this material is in the construction industry as the composition of this waste can help in replacing one of the raw materials of concrete.

Marble dust powder is a powder that is collectively obtained from the marble industry and can be found abundantly. These are very fine particles that are considered as an end product from such industries which is obtained by cutting the marbles. The generation of this waste is generally about 20% of the total marble used. The amount of this marble waste powder is huge when it is removed from the industry and the rough estimate of the amount is 250-400 tones. Again, the disposal problem arises and many new green methods of disposal are studied and are being used in the modern world. Due to its easy availability and low cost, its applications are wide. In the construction field, this wastage when combine with cement (pozzolans), enhances the strength and durability of concrete.

II. Objectives

Following were the objectives of current experimental work:

1. To study the application and benefits of waste material i.e. glass powder and marble dust in concrete.

2. Control mix M25 grade of concrete is to be prepared as per the codal provisions of concrete design mix.
3. To examine the effect on concrete when raw cement was replaced with marble powder (4, 8%, 12% and 16%) and glass powder (4, 8%, 12% and 16%).
4. To compare the new green concrete with control mix concrete.
5. To recommend the optimum combine proportions of all the replacement materials used in concrete.

III. RESULTS

The present chapter represents all the results of laboratory tests which were conducted for the current thesis work. The results of Slump Test, Compressive Strength Test, Split Tensile Strength Test and Flexural Strength Test are shown in the following sections.

SLUMP TEST RESULTS

Table 1. and fig. 1 represents the results which were collected during the slump test and were used for comparison purpose.

Table 1: Results of Slump Test.

S. No.	Concrete Mix	Slump Value, mm
1	CM	85
2	MP4GP4	81
3	MP8GP8	71
4	MP12GP12	72
5	MP16GP16	64

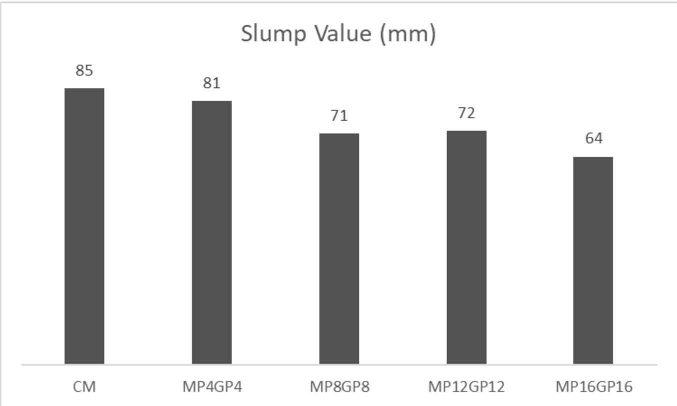

Figure 1. Slump Test Results of Various Concrete Mixes.

It can be clearly seen from fig 1 that the slump value of concrete mix tends to decrease when the cement is replaced with glass powder and marble powder. The slump for control mix concrete was 85 mm whereas the lowest slump value was observed for MP16GP16 i.e. 64 mm.

COMPRESSIVE STRENGTH TEST RESULTS

Table 2: Results of Compressive, Split Tensile and Flexural Strength Test.

Mix Design	At 7 days	% Change at 7 days	At 28 days	% Change at 28 days
CM	22.87	-	32.48	-
MP4GP4	23.65	3.41	33.24	2.34
MP8GP8	24.41	6.73	34.98	7.70
MP12GP12	24.08	5.29	33.12	1.97
MP16GP16	22.61	-1.14	31.09	-4.28

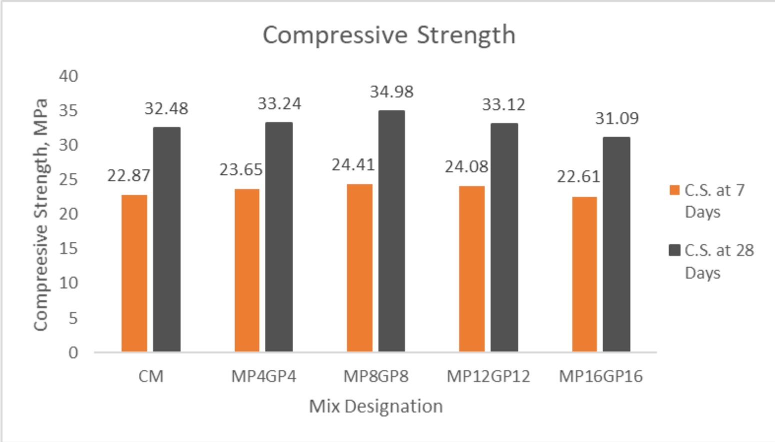

Figure 2. Compressive Strength at different curing period.

The initial compressive strength at 0% replacement was 22.87 MPa and 32.48 MPa after 7 days and 28 days of curing period. When waste marble powder and Glass powder was added, a gradual increase in the compressive strength was observed as shown in fig. 2. The maximum compressive strength was gained when 8% of marble Powder and 8% of glass powder (i.e. MP8GP8) was added to the concrete mix. The respective strength of MP8GP8 was 24.41 MPa and 34.98 MPa at 7 days and 28 days of curing period. Then beyond MP8GP8, the compressive strength decreases and continues to decrease for the higher proportion of glass powder and marble powder i.e. 12% & 16%. At 16% of marble powder and 16% of Glass powder (i.e. MP16GP16), the compressive strength at 7 days and 28 days comes out to be 22.61MPa and 31.09 MPa respectively.

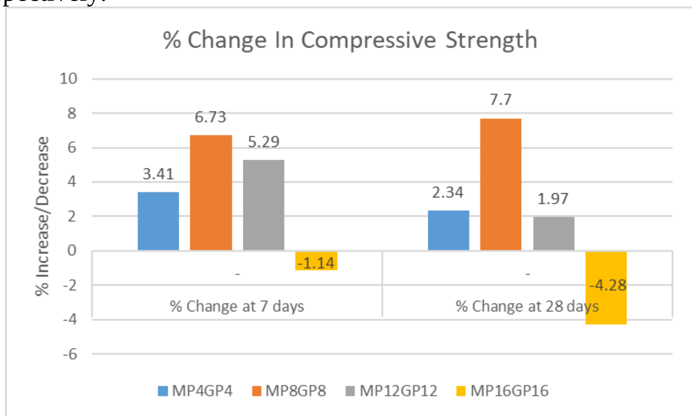

Figure 3. Percentage Change in Compressive Strength at 7 and 28 days.

From the fig. 3, it can be observed that the maximum increase in compressive strength was 6.73% and 7.7% at 7 days and 28 days respectively for MP8GP8 when compared to control mix concrete. However, there is a decrease in compressive strength of 1.14% and 4.28% at 7 days and 28 days respectively for MP16GP16 when compared to control mix concrete.

SPLIT TENSILE STRENGTH TEST RESULTS

Table 3. Split Tensile Strength Test Results of Various Concrete Mixes.

Mix Design	At 7 days	% Change at 7 days	At 28 days	% Change at 28 days
CM	2.71	-	3.95	-
MP4GP4	3.09	14.02	4.26	7.85
MP8GP8	3.24	19.56	4.51	14.18
MP12GP12	3.37	24.35	4.65	17.72
MP16GP16	2.55	-5.90	3.46	-12.41

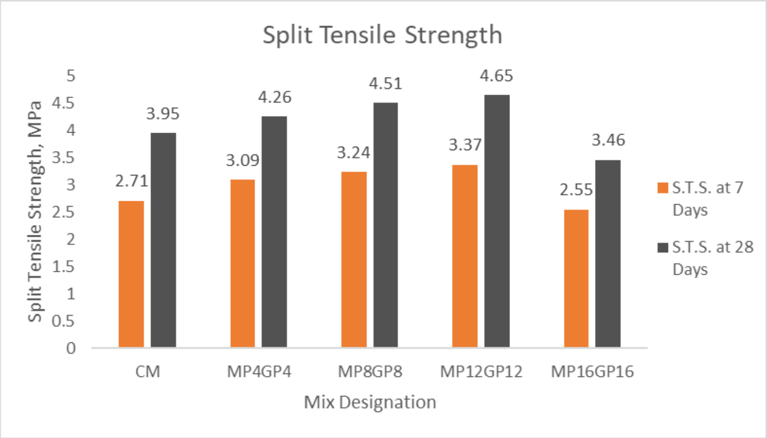

Figure 4. Split Tensile Strength at different curing period.

The initial split tensile strength at 0% replacement was 2.71 MPa and 3.95 MPa after 7 days and 28 days of curing period. When waste marble powder and Glass powder was added, a gradual increase in the split tensile strength was observed as shown in fig. 4. The maximum split tensile strength was gained when 12% of marble Powder and 12% of glass powder (i.e. MP12GP12) was added to the concrete mix. The respective strength of MP12GP12 was 3.37 MPa and 4.65 MPa at 7 days and 28 days of curing period. Then beyond MP12GP12, the split tensile strength decreases and continues to decrease for the higher proportion of glass powder and marble powder. At 16% of marble powder and 16% of Glass powder (i.e. MP16GP16), the split tensile strength at 7 days and 28 days comes out to be 2.55 MPa and 3.46 MPa respectively.

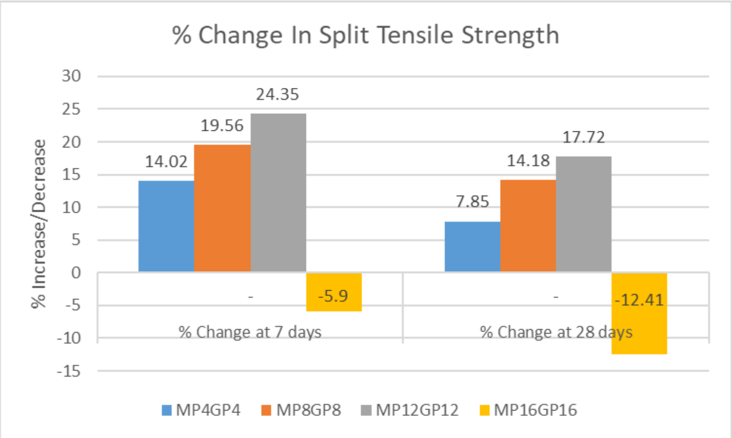

Figure 5. Percentage Change in Split Tensile Strength at 7 and 28 days.

From the fig. 5, it can be observed that the maximum increase in split tensile strength was 24.35% and 17.72% at 7 days and 28 days respectively for MP12GP12 when compared to control mix concrete. However, there is a decrease in split tensile strength of 5.9% and 12.41% at 7 days and 28 days respectively for MP16GP16 when compared to control mix concrete.

FLEXURAL STRENGTH TEST RESULTS

Table 4. Flexural Strength Test Results of Various Concrete Mixes.

Mix Design	At 7 days	% Change at 7 days	At 28 days	% Change at 28 days
CM	2.96	-	4.76	-
MP4GP4	3.08	4.05	4.95	3.99
MP8GP8	3.2	8.11	5.06	6.30
MP12GP12	3.32	12.16	5.18	8.82
MP16GP16	2.84	-4.05	4.35	-8.61

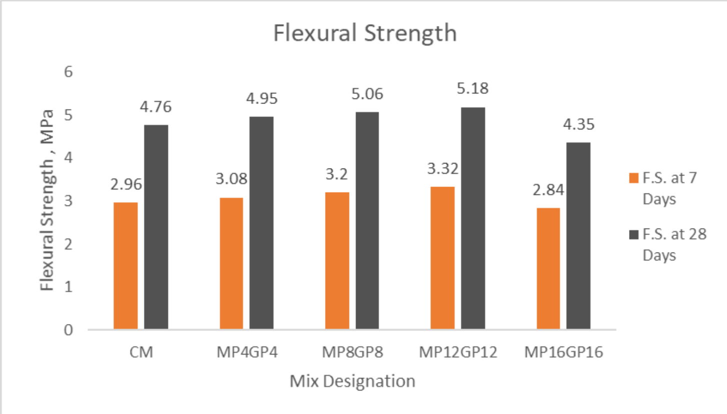

Figure 6. Flexural Strength Test Results at different curing period.

The initial Flexural strength at 0% replacement was 2.96 MPa and 4.76 MPa after 7 days and 28 days of curing period. When waste marble powder and Glass powder was added, a gradual increase in the Flexural strength was observed as shown in fig. 6. The maximum split tensile strength was gained when 12% of marble Powder and 12% of glass powder (i.e. MP12GP12) was added to the concrete mix. The respective strength of MP12GP12 was 3.32 MPa and 5.18 MPa at 7 days and 28 days of curing period. Then beyond MP12GP12, the split tensile strength decreases and continues to decrease for the higher proportion of glass powder and marble powder. At 16% of marble powder and 16% of Glass powder (i.e. MP16GP16), the split tensile strength at 7 days and 28 days comes out to be 2.84 MPa and 4.35 MPa respectively.

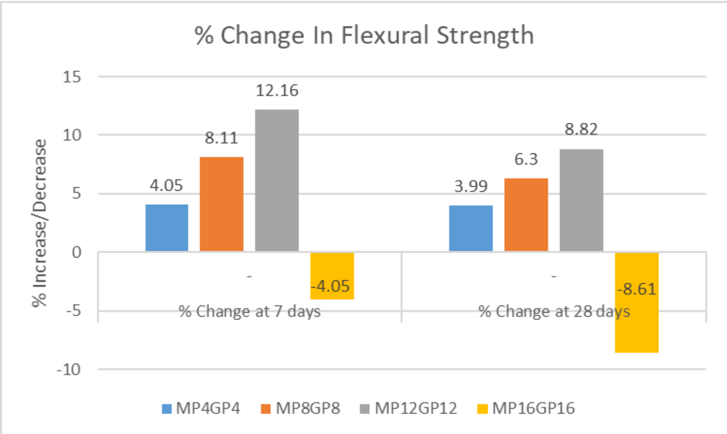

Figure 7. Percentage Change in Flexural Strength at 7 and 28 days.

From the fig. 7, it can be observed that the maximum increase in Flexural strength was 12.16% and 8.82% at 7 days and 28 days respectively for MP12GP12 when compared to control mix concrete. However, there is a decrease in Flexural strength of 4.05 % and 8.61% at 7 days and 28 days respectively for MP16GP16 when compared to control mix concrete.

IV. Conclusions

The final conclusions of the current experimental study work have been mention below:

- The initial compressive strength at 0% replacement was 22.87 MPa and 32.48 MPa after 7 days and 28 days of curing period. It can be concluded from the results that the maximum increase in compressive strength was 6.73% and 7.7% at 7 days and 28 days respectively for MP8GP8 when compared to control mix concrete. However, there is a decrease in compressive strength of 1.14% and 4.28% at 7 days and 28 days respectively for MP16GP16 when compared to control mix concrete.
- The initial split tensile strength at 0% replacement was 2.71 MPa and 3.95 MPa after 7 days and 28 days of curing period. It can be concluded from the results that the maximum increase in split tensile strength was 24.35% and 17.72% at 7 days and 28 days respectively for MP12GP12 when compared to control mix concrete. However, there is a decrease in split tensile strength of 5.9% and 12.41% at 7 days and 28 days respectively for MP16GP16 when compared to control mix concrete.
- The initial Flexural strength at 0% replacement was 2.96 MPa and 4.76 MPa after 7 days and 28 days of curing period. It can be concluded that the maximum increase in Flexural strength was 12.16% and 8.82% at 7 days and 28 days respectively for MP12GP12 when compared to control mix concrete. However, there is a decrease in Flexural strength of 4.05 % and 8.61% at 7 days and 28 days respectively for MP16GP16 when compared to control mix concrete.
- Therefore, it is recommended that 8 to 12% of glass powder with 8 to 12% of marble powder can be used as an effective replacement material for cement in concrete mix to attain improved strength parameters.

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